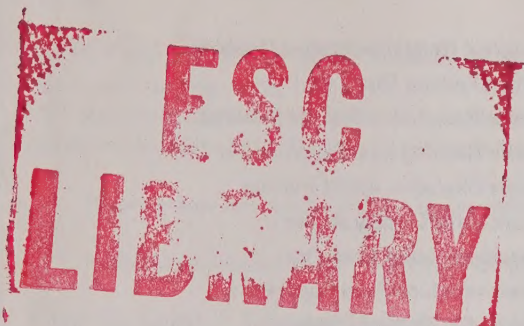




Option —05 IEEE Standard 488-1975 Interface

605-1. INTRODUCTION

605-2. The IEEE Standard 488-1975 Interface (hereinafter referred to as the IEEE Interface) has been designed in accordance with IEEE STANDARD DIGITAL INTERFACE FOR PROGRAMMABLE INSTRUMENTATION published by the Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017. Familiarity with this standard is assumed and no attempt will be made in this manual to cover all the material contained in the standard.

605-3. INSTALLATION

605-4. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing modules. The IEEE Interface module should be placed in the rearmost slot of the instrument so the cable connector and address switches are accessible through the hole in the rear panel. The interconnect diagram in Section 8 contains a table listing the permissible and preferred slots for each

module. The Isolator module (Option-08A) must replace the interconnect pcb. Connection to the system is made with an IEEE Standard 24-pin cable available from the John Fluke Mfg. Co. Cable lengths of 1, 2, and 4 meters are available (P/N's Y8001, Y8002, and Y8003 respectively). The cable shield (pin 12 in the connector) is brought out with a banana jack for access from the rear panel. It may be connected to chassis ground with a binding post provided on the rear panel at the discretion of the system designer. Address switches (A1-A5) must be set by the user. Depressing the switch toggle to the bottom ident sets that particular address bit TRUE. TALK address bits T1 through T5 are equal to LISTEN address bits L1 through L5. The instrument may be placed in the Talk Only mode with the Talk/Addressable switch accessible through the rear panel, if other devices in the system are listeners only.

605-5. PROGRAMMING INSTRUCTIONS

605-6. Programming instructions are contained in Table 605-1. A programming command summary is contained in Table 605-2.

Table 605-1. Programming Instructions

PROGRAM SEQUENCE

When programming the instrument remotely, there is a sequence of commands that will determine the range, function, speed, etc., of the instrument. When power is applied or a reset character is transmitted, the instrument assumes a starting or "reset" condition. The "reset" condition is defined as follows:

REMOTE CODE	COMMAND
V	Volts DC
R4	1000V Range
S 7	27 Samples Per Reading
F0	Fast Filter, Timeout Disabled (Panel Indicator OFF)

Table 605-1. Programming Instructions (Continued)

REMOTE CODE	COMMAND
X0	External Reference/Scaling Disabled
P0	Offset Feature Disabled
U0	Limits-Peak Value Storage Disabled
T0	Single Reading Line Synchronous
B0	Single Character ASCII Format
D0	Front Panel Display Active
L0	Deactivate Local Lock Out
J0	Deactivate Line Feed Suppression
M0	Enable Cal Memory Factors

FUNCTION	STATE ASSUMED
Remote/Local	Local
Offset	Zeroed
V dc Zero	Zeroed (Retained if Cal Memory Option -04 Installed)
Ohms Zero	Zeroed (Retained if Cal Memory Option -04 Installed)
Cal Memory Factors	Retained (Applicable Only When Cal Memory Option -04 Installed)
Peak Values	Zeroed
Limits Values	Zeroed
Ext. Ref/Scaling Values	Zeroed

The instrument, when equipped with any of the remote interface options, is programmed through a "command string" format. All characters transmitted via the remote interface must be ASCII 7-bit upper case characters. A command string is a sequence of 1 to 31 characters, consisting of one or more of the following character types: IMMEDIATE, COMMAND, and TERMINATION. The instrument may be placed in Remote Mode by toggling the front panel REMOTE pushbutton or by transmitting any character that the instrument will recognize from the remote controlling terminal. When in Remote Mode, the only front panel switch that is active is the REMOTE switch, providing that it is not locked out by the local lockout command.

IMMEDIATE CHARACTERS

There are five immediate characters so named since they cause an immediate action. An immediate character may be executed at any time and does not require a termination character.

*** Reset**

The immediate character "*" sets the instrument to a "reset" condition as described in an earlier paragraph. When this command is issued, it must not be followed by any character for approximately 3 second; e.g., any carriage return and/or linefeed following the "*" must be suppressed. This is required because the microprocessor resets the remote interface as well as the instrument. During this period, the remote interface is unable to accept programming characters.

Table 605-1. Programming Instructions (Continued)

% Halt

The "%" character is used to halt a reading which is in progress; in particular if the instrument has been placed into the continuous reading mode, that mode will be terminated and the instrument will wait for a command string. When the "%" character is received, the transmission of readings is terminated immediately even if a reading has not been completely transmitted. The following trigger mode transitions will occur:

If continuous line synchronous — single reading line synchronous

If continuous asynchronous — single reading asynchronous

Note: In practice no characters should precede the halt "%" character when already in the continuous mode.

Go To Local — Lockout Remote

The "#" character will command the instrument to enter local mode of operation and lockout the remote interface. The remote mode can be reentered only after the front panel REMOTE button has been pushed.

NOTE: The state of the instrument when changing from remote to local operation will be modified as follows:

Ohms fast mode will be ignored

The state of the instrument when changing from local to remote operation will be modified as follows:

Ohms fast mode, and continuous mode will be resumed if the instrument was in that mode when it was placed into local.

The last local error that occurred (if any) will be remembered and be available for recall by "getting" status.

TERMINATION CHARACTERS

Termination characters cause the execution of a command string. They are normally placed at the end of each programming statement.

\$ Clear the Command String

The "\$" character is used to erase an incorrect programming entry from the command string buffer. It deletes all characters issued back to, but not including, the preceding termination character. A new command string is then needed to modify the state of the instrument. This character is normally used only when operating in an immediate mode, such as with an unintelligent terminal.

, Execute the Command String

The "," character is used to cause the execution of the previous command string. It does not trigger a reading or produce a response from the instrument; it puts the instrument in the defined state only. When programming a string of characters, it is a good practice to use the execute character "," at frequent intervals so that if an error is made, the string need only be cleared back to the last ",".

Table 605-1. Programming Instructions (Continued)

? Execute The Command String and Trigger

The "?" character will cause the execution of a previously entered command string (if any), take a reading and transmit that reading through the remote interface. If a command string was not entered immediately preceding the "?" character, the instrument will be in the last defined state and in that state take and transmit a reading.

One exception occurs when a command string containing a "get" specification has been entered; in that case, the instrument will respond with the value or status that was requested by the command string. (Note: in this case no reading is triggered)

*

@ Execute, Trigger, and Interrupt When Ready

The "@" character is used to cause the triggering of a reading and the generation of an interrupt when the reading is done. The function of the "@" termination character is in all other respects similar to the "?" termination character. The method of providing an interrupt is that the interface asserts a service request on the IEEE-488 bus. In order to obtain the reading that was generated by "@" termination character, a "G" command should be inserted in the following command string, terminated by a "?" character.

*

COMMAND CHARACTERS

The command characters can be divided into five groups:

Function

(DC and AC Volts, DC and AC Amps, Ohms, and Fast Ohms)

Range

(Discrete Range or Autorange)

Modifiers

Sample Rate (readings per second), Filter (slow, fast, bypass, time-out), Trigger (continuous, single, synchronous, asynchronous), Offset (offset on-off), External Reference (on-off scaling), Ultimeates (on-off limits), External trigger (with SRQ, without SRQ, off) External trigger, timeouts

*

Control

(Binary or ASCII Output, Display On-Off, Local Lockout, Echo)

Memory

(Value Stored For: V DC at Ohms, Zero, Offset, Ext Ref, Numeric Entry Upper and Lower limits, scaling, offset, (Values Recalled For: Previous Reading, DC Zero, Status, Offset, Ext Ref, scaling upper limit, lower limit, upper peak, lower peak.

*

Table 605-1. Programming Instructions (Continued)

FUNCTION COMMAND CHARACTERS

There are 7 functions command characters. The following characters select the multimeter functions.

V	— DC Volts
VA	— AC Volts
C	— DC Coupled AC Volts
I	— DC Current
IA	— AC Current
Z	— Ohms
Z1	— Fast Ohms

When the function is changed, the state of the instrument is changed as follows:

Range

Auto

Modifiers

Unchanged except that the "Offset" scaling, limits, peaks modes are turned off but stored values are not lost.

Control

Unchanged

Memory

Unchanged

If a function is selected which requires an optional module which is not loaded, the function of the instrument will be undefined and the error code will be set to 19.

Z1 Function Command Character

The "Z1" character string will place the instrument into the ohms function and fast ohms mode. In normal ohms operation, the unknown resistor value R_x is determined by three measurements:

$V_1 - V_2$ which is the voltage across an internal precision reference R and V_0 which is the voltage across the unknown resistor R_x .

The value R_x is then computed by the application of Ohm's Law.

$$R_x = R_r \left[V \div (V_1 - V_2) \right]$$

In the fast ohms mode, $R_r/(V_1 - V_2)$ is stored and assumed to be constant until a function change, range change, or overrange condition occurs. The instrument measures V_0 and multiplies by the constant $R_r/(V_1 - V_2)$ to obtain the result, R_x . In the slow ohms mode, all voltages (V_0 , V_1 , and V_2) are measured to calculate R_x .

Table 605-1. Programming Instructions (Continued)

R Range Command Characters

There are nine range commands which will specify the following by function:

	C		I	IA	Z, Z1
	V	VA			
	DC VOLTS	AC VOLTS	DC CURRENT	AC CURRENT	OHMS
R	Auto	Auto	Auto	Auto	Auto
R0	312.5 mV	Auto	312.5 μ A	312.5 μ A	21.25 Ω
R1	2.5V	2.5V	2.5 mA	2.5 mA	250 Ω
R2	20V	20V	20 mA	20 mA	2 k Ω
R3	160V	160V	160 mA	160 mA	32 k Ω
R4	1280V	1280V	1.280A	1.280A	256 k Ω
R5	Auto	Auto	Auto	Auto	4.096 M Ω
R6	Auto	Auto	Auto	Auto	32.768 M Ω
R7	Auto	Auto	Auto	Auto	262.144 M Ω

NOTE: Values shown are full scale values for each function and range.

MODIFIER COMMAND CHARACTERS

There are 7 modifier command characters:

S — Sample Rate
F — Filter
T — Trigger
P — Offset

X — External Reference — Scaling
U — Ultimates — Limits
H — Hi-Averaged Sample Rate
Q- Ext. Trigger
W- Ext. Trigger Delays

S or H Samples/Reading

The modifier command character "S" is followed by a digit (0 through 7) specifying the number of samples per readings as follows:

S0 — $2^0 = 1$ Sample/Reading (4 mS)
S1 — $2^1 = 2$ Samples/Reading (8 mS)
S2 — $2^2 = 4$ Samples/Reading (17 mS)
S3 — $2^3 = 8$ Samples/Reading (33 mS)

S4 — $2^4 = 16$ Samples/Reading (67 mS)
S5 — $2^5 = 32$ Samples/Reading (134 mS)
S6 — $2^6 = 64$ Samples/Reading (267 mS)
S7 — $2^7 = 128$ Samples/Reading (534 mS)

The modifier command character "H" is followed by a digit (0 through 9). The "H" modifier command character is an extension of the "S" modifier command character. The next higher sample rate above S7 is H0.

H0 — $2^8 = 256$ Samples/Reading (1.1S)
H1 — $2^9 = 512$ Samples/Reading (2.1S)
H2 — $2^{10} = 1,024$ Samples/Reading (4.3S)
H3 — $2^{11} = 2,048$ Samples/Reading (8.5S)
H4 — $2^{12} = 4,096$ Samples/Reading (17.1S)

H5 — $2^{13} = 8,192$ Samples/Reading (34.1S)
H6 — $2^{14} = 16,384$ Samples/Reading (68.3kS)
H7 — $2^{15} = 32,768$ Samples/Reading (2 Min 17S)
H8 — $2^{16} = 65,536$ Samples/Reading (4 Min 33S)
H9 — $2^{17} = 131,072$ Samples/Reading (9 Min 6S)

NOTE: The times shown above are approximate digitizing times per reading for 60 Hz line synchronous operation with either dc volts, current, or ac volts functions programmed.

Table 605-1. Programming Instructions (Continued)

F Filter

The "F" character is used to specify the amount of filtering and whether a (software) time-out for the filter settling time is to be enabled. The time-out causes a delay between a trigger command received and the actual reading to be taken. In the continuous trigger modes, the time-out will occur before each reading is initiated. Since there are two filter bandwidth settings, there are two time-outs; one associated with slow filter (approximately 500 mS) and one associated with fast filter (approximately 50 mS). The following "F" modifier command characters are recognized:

F — Slow, Filter, Time-Out Disabled

F2 — Slow Filter, Time-Out (approximately 500 mS) Enabled

F0 — Fast Filter, Time-Out Disabled

F3 — Fast Filter, Time-Out (approximately 50 mS) Enabled

F1 — Bypass Filter, Time-Out Disabled

T Trigger

The "T" character specifies the trigger mode of the instrument, it will select whether samples to be averaged for a reading are taken line synchronous (every 4 or 5 ms) or line asynchronous (approximately every 1.7 ms), and whether a single reading is to be taken or continuous readings.

T — Continuous Reading Mode/Line Synchronized

T1 — Continuous Reading Mode/Line Asynchronous

T0 — Single Reading Mode/Line Synchronized

T2 — Single Reading Mode/Line Asynchronous

NOTE: When line asynchronous modes are selected, the display will be turned off in order to save time; the front panel switches with the display off are ignored.

While in the continuous mode no characters other than "%" should be sent. This **P Offset** will confuse the 8502A or the operator.

The "P" character specifies whether a reading is to have an offset subtracted from it.

P — Offset Subtracted (ON)

P0 — Offset Not Subtracted (OFF)

The offset value may be stored either by entry from front panel, storing a previous reading as an offset or storing a numerically entered offset.

X External Reference — Scaling

The "X" character sets the external reference/scaling mode. This mode is valid for any function and any range. In this mode, all readings are divided either by the signed magnitude of the external reference voltage in volts or by a numerically entered scale factor or previously taken external reference voltage.

X — External Reference "On", Scaling "Off"

X1 — External Reference "Off", Scaling Mode 'On

X0 — Scaling Mode 'Off External Reference "Off"

The "X" external reference mode uses the external reference voltage V_{xref} as a dividing scale factor. Every reading cycle this voltage is measured and all readings are divided by this measured voltage.

Minimum $V_{xref} = \pm 0.0001V$, or $V_{input} \div$ maximum display within range Volts, whichever is greater. (See specifications in Section 1 for maximum display value.)

Maximum $V_{xref} = \pm 40V$ between EXT Ref Hi and Lo Terminals, providing neither terminal is greater than $\pm 20V$ relative to the Sense Lo or Ohms Guard Terminals.

Reading = INPUT $\div$ V_{xref}

Table 605-1. Programming Instructions (Continued)

The "X1" scaling mode will divide all readings by a previously taken external reference voltage or by a previously entered numeric scale factor SF which has a range given by

Minimum SF = Same as V_{xref} minimum

Maximum SF = ± 100

Reading = $INPUT \div SF$

The "X" and "X1" modes are mutually exclusive; i.e., only one may be activated at any one time. Note that in conjunction with the offset feature any linear transformation of the form

$$y = mx + b$$

can be programmed where "x" is the unscaled reading, "-b" is the stored offset, "m" is the stored value "1/SF" and "y" is the final displayed reading. The value "y" may be interpreted in any units appropriate to the user since the scaling factor may be constructed so as to give any desired units within the display limits of the instrument.

U Limits – Peak Value Storage

The "U" character specifies whether a test for limits (or Peak Value Storage) is to be performed. In the limits "On" mode, each reading is compared to upper and lower limits which have been entered with a keep command (see section Memory "Keep" Characters).

"0" is transmitted for between limits and a

"1" is transmitted for above upper limit

"-1" is transmitted for below lower limit

"2" is transmitted if an error occurs (such as over-ranging)

The total output format then is 3 or 4 ASCII characters.

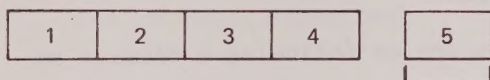
SIGN	0/1/2	CR	LF
U – Limits Testing On (Values Must be Preset) U0 – Disable Limits/Peak Value Storage U1 – Save Lower and Upper Values (Peak Values) Previous lower and upper values are erased from memory whenever "U1" is programmed Limits may be stored by "Keeping" a numeric value as lower or upper limit. <i>NOTE: Limit tests are applied after all other modifier modes such as scaling, offset, etc. have been applied.</i> CONTROL COMMAND CHARACTERS There are 6 control command characters: B – Binary or ASCII Output Format J – Inhibit (LF) D – Display ON/OFF M – No cal adjustment L – Local Lockout B Output Format The "B" character selects the binary or ASCII output format. B – Binary Format B0 – ASCII Format			

Table 605-1. Programming Instructions (Continued)

The display mode is turned on when the ASCII mode is entered, off when Binary mode is entered.

THE BINARY OUTPUT FORMAT:

The binary output format consists of five characters:

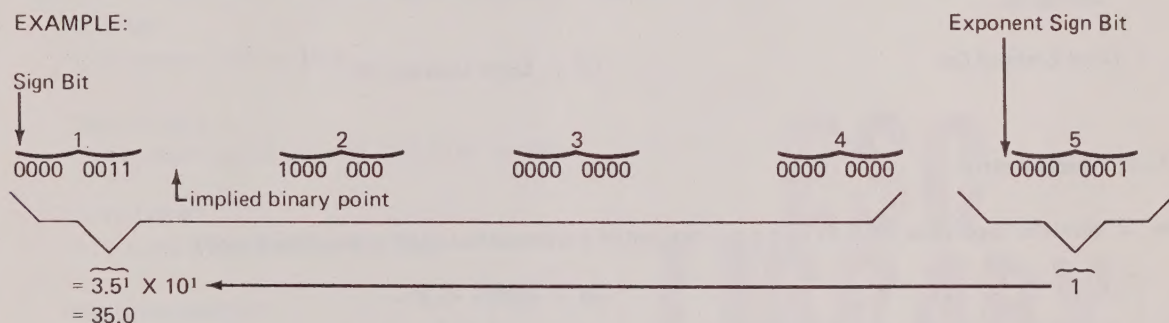


Decimal exponent (two's) complement

The implied binary point is between first and second character.

The first four characters contain a 32-bit binary two's complement fixed point number. The fixed binary point is located between the first and second characters giving 8 bits as the integer portion and 24 bits of binary fraction. Because this format cannot be used to hold the entire range of possible values for the DMM, a fifth character is used as an exponent. The exponent is an 8-bit two's complement binary number representing the decimal exponent of the 32-bit binary fixed point number contained in the first 4 characters.

EXAMPLE:

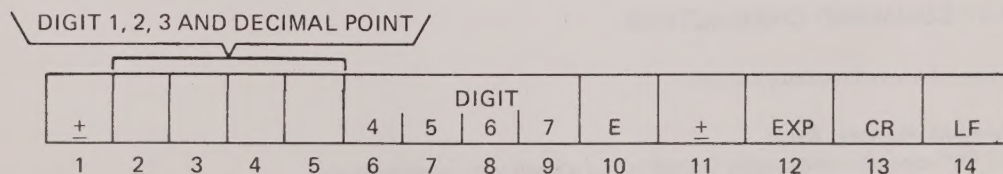


NOTE 1: In dc volts and ac volts, the exponent is always 1. In dc and ac current, the exponent is always -2. The exponent is range dependent in ohms function; i.e., 1 for Ω ranges, 4 for $k\Omega$ ranges, and 7 for $M\Omega$ ranges.

NOTE 2: When in binary mode with limits testing activated the response is a single byte 8 bit binary two's complement number.

THE ASCII DATA OUTPUT FORMAT:

The ASCII data format consist of 14 characters:



The seventh digit in the ASCII format corresponds to the "Cal" digit of the front panel display. In some ranges and functions (e.g., 100 mV dc) this digit is permanently zeroed since it exceeds the resolution of the instrument. (When in the "Cal" mode, the front panel will display the value of the reading rounded to 6 significant digits.)

Table 605-1. Programming Instructions (Continued)

D Display Control

The "D" command turns the display on or off. With the display off, the instrument is no longer interrogating any of the front panel switches; so turning the display off causes a local lockout condition.

D — Display Off

D0 — Display On

The display is also turned off when the binary mode command is sent to and on following a command to enter the ASCII mode.

*

L Local Lockout Control

The "L" character places the instrument in or out of local lockout. In the local lockout mode, none of the switches will affect the instrument; however, the display will not be turned off.

NOTE: When NOT in the local lockout mode, the remote switch on the instrument front panel can be used to toggle between the local mode (with continuous readings and full enabling of switches) and the remote mode (where only the remote switch is interrogated by the instrument and readings are taken only if requested by the remote interface).

L — Local Lockout On

L0 — Local Lockout Off

J Line Feed Control

The "J" character suppresses the (LF) sent out at the end of a response line. "J0" is the default mode.

J — <CR>

J0 — <CR> <LF>

J1 — Inhibit output of reading but not output of SRQ or status or any recalled value.

*

M Calibration Constant

The "M" character inhibits the adjustment of readings by the calibration memory correction factor. This will slightly increase the speed of readings. It has no effect if calibration memory Option -04 is not installed.

M — Cal constant not applied

M0 — Cal constant applied

MEMORY COMMAND CHARACTERS

There are two forms of memory control:

Store into Memory: Keep;

The "K" character will specify the storing of a reading or numeric entry.

Recall from Memory: Get;

The "G" character specifies that a reading, numeric entry or status is to be read from memory.

The "?" termination character is used in conjunction with any GET response.

*

Table 605-1. Programming Instructions (Continued)

K "Keep" Command Characters

The following memory "Keep" commands are recognized:

K — Keep Last Reading as Offset

K0 — Keep Last Voltage Taken as V DC Zero*

K1 — Keep Last Reading as Ohms Zero*

KNP — Keep Numeric Value Following as Offset

KNX — Keep Numeric Value Following as Scaling Factor

KNU — Keep Numeric Value Following as Upper Limit

KNL — Keep Numeric Value Following as Lower Limit

*May only be performed on lowest range (R0).

NUMERIC ENTRY FORMAT

Offsets, Scaling Factors, Upper and Lower Limits may be entered via the "KN" command characters followed by one of the modifier characters "P", "X", "U" or "L" and the numeric value which is an ASCII string of numeric characters, and optional sign, decimal point and signed decimal exponent digit in "E" notation.

Examples of legal numeric strings are:

"KNP10"

Keep numeric offset of 10.0

"KNX10.3E-1"

Keep numeric scaling factor of 10.3×10^{-1} or 1.03

"KNU7.6E4"

Keep numeric upper limit of 7.6×10^4

"KNL-123.456E+0"

Keep numeric lower limit of -123.4567

Some illegal strings are:

"KNX2.0E-13"

Exponent is limited to one signed integer digit, in this case the exponent would be -1 and the "3" would be ignored.

NOTE: Numeric values are limited to the maximum display value. These values are +1.00000E+9 to +1.00000E-9 and -1.00000E-9 to 1.00000E+9. Numbers less than +1.00000E-9 are treated as zero - (0.00000 E-9)

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Table 605-1. Programming Instructions (Continued)

G "Get" Command Characters

The following memory "Get" commands may be used:

- | | |
|--|---|
| G — Get Previous Reading and send on next Trigger | GNU — Get Upper Limit and send on next Trigger |
| G0 — Get DC Zero and send on next Trigger | GNL — Get Lower Limit and send on next Trigger |
| G1 — Get Status and send on next Trigger (see status format next paragraph) | GNQ — Get Lowest Value Found and send on next Trigger |
| GNP — Get Offset and send on next Trigger | GNW — Get Highest Value Found and send on next Trigger |
| GNX — Get /Scaling factor and send on next Trigger | |

GNR -Get External Reference value and send on next trigger.

NOTE: The "Get" commands must be followed by a trigger character "?".

Status Format

Status information from the instrument may be obtained in the following format with memory command character "G1?."

Character 1 and 2 of the status information contain error code:

- | | |
|---|---|
| 00 — No error | 13 — DC Amp Module Faulty or not installed |
| 06 — System Error | 14 — Excessive voltage present at terminals for Ohms/Current Measurement |
| 07 — Illegal Numeric Entry | 15 — Fast A/D Converter Faulty or not installed |
| 08 — Remote Command String Error | 16 — Numeric Display Overflow |
| 09 — Remote Overrange | 17 — Magnitude of External Reference Input >20V |
| 10 — V DC Zero/Ohms Zero Error | 18 — Controller Module Faulty |
| 11 — Store of overrange | 19 — Function Module selected not installed |
| 12 — Filter Module Faulty or not installed | |

NOTE: The least significant digit of the error code is displayed on the front panel; error codes with a first digit of zero are related to remote operation only.

Character 3 of the status information contains the range information (see table in "Range Command Characters" on Page 6).

Character 4 of the status information contains the sample rate (2y) low sample rate only.

Character 5 of the status information contains the function code:

- | | |
|---------------------|---------------------------------|
| 0 — DC Volts | 4 — Ohms |
| 1 — AC Volts | 5 — DC Coupled AC |
| 2 — DC Amps | 7 — Function Not Defined |
| 3 — AC Amps | |

1	2	3	4	5	(CR)	(LF)
ERROR CODES		RANGE CODES	SAMPLE RATE	FUNCTION	CARRIAGE RETURN	LINE FEED

Table 605-1. Programming Instructions (Concluded)

Example Command Strings

The following is an example of different command strings and an explanation.

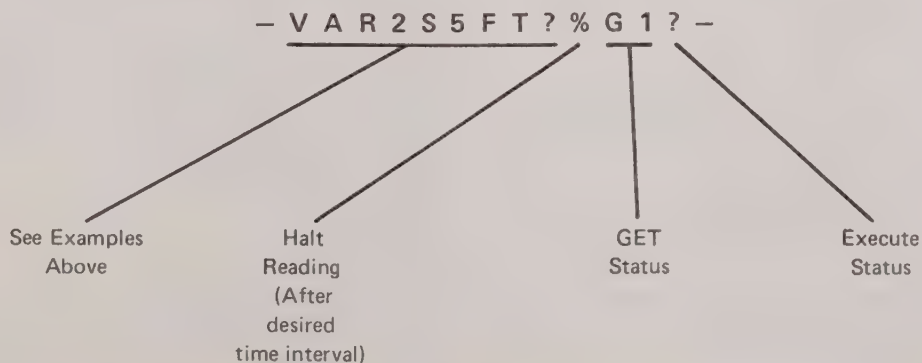
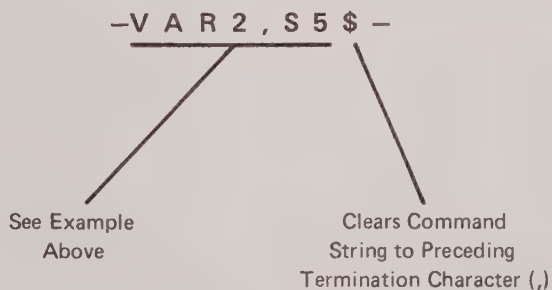
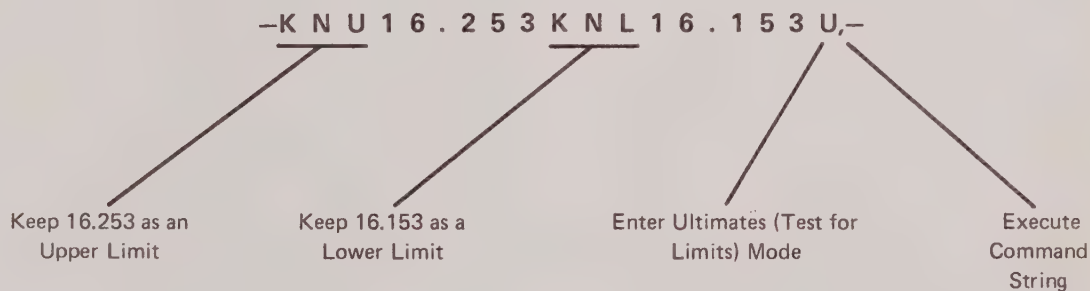
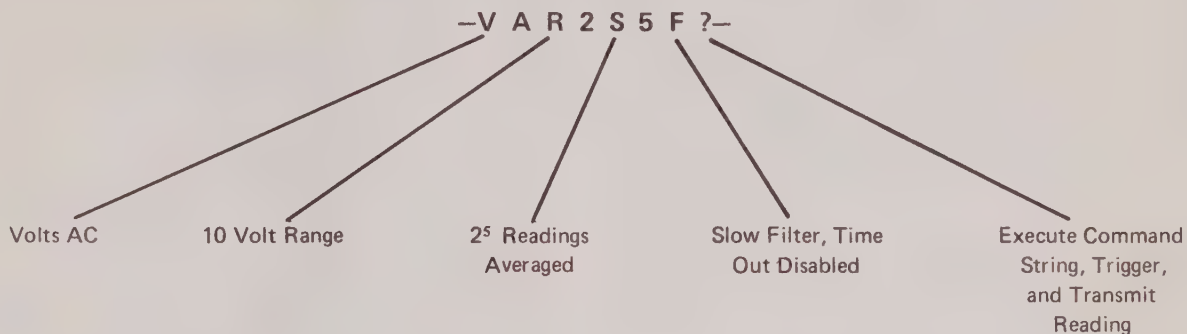


Table 605-2. Programming Commands

IMMEDIATE CHARACTERS	
Code	Explanation
*	Reset
G	Halt
#	Go to local/lockout remote
!	Enter high-speed reading mode
\$	Clear command string buffer
	Toggle the parallel interface mode

TERMINATION CHARACTERS	
.	Execute previous command string
"	Execute, trigger and transmit reading
(a)	Execute and trigger interrupt when ready

COMMAND CHARACTERS	
	Function Commands
V	DC Volts
VA	AC Volts
C	DC coupled AC Volts
I	Direct Current
IA	Alternating Current
Z	Ohms (Ω)
Z1	Ohms function fast mode activated
R	Range Commands
R0	Autoranging
R1	100 mV dc, 100 μ A, 10 Ω , Vac autoranging
R2	1V dc, 1V ac, 1 mA, 1 k Ω
R3	10V dc, 10V ac, 10 mA, 1 k Ω
R4	100V dc, 100V ac, 100 mA, 10 k Ω
R5	1000V dc, 1000V ac, 1A, 100 k Ω
R6	1 M Ω , other functions autoranging
R7	10 M Ω , other functions autoranging
S0	2 ⁰ samples per reading (4 ms)
S1	2 ¹ samples per reading (8 ms)
S2	2 ² samples per reading (17 ms)
S3	2 ³ samples per reading (33 ms)
S4	2 ⁴ samples per reading (67 ms)
S5	2 ⁵ samples per reading (134 ms)
S6	2 ⁶ samples per reading (267 ms)
S7	2 ⁷ samples per reading (534 ms)
H0	2 ⁸ samples per reading (1.1 sec)
H1	2 ⁹ samples per reading (2.1 sec)
H2	2 ¹⁰ samples per reading (4.3 sec)
H3	2 ¹¹ samples per reading (8.5 sec)
H4	2 ¹² samples per reading (17.1 sec)
H5	2 ¹³ samples per reading (34.1 sec)
H6	2 ¹⁴ samples per reading (68.3 sec)
H7	2 ¹⁵ samples per reading (2 min. 17 sec)
H8	2 ¹⁶ samples per reading (4 min. 33 sec)
H9	2 ¹⁷ samples per reading (9 min. 6 sec)
F	Filter Commands
F0	Slow filter, time out disabled (panel indicator ON)
F1	Fast filter, time out disabled (panel indicator OFF)
F2	Filter bypassed
F3	Slow filter, time out delay (500 ms) (panel indicator ON)
F4	Fast filter, time out delay (50 ms) (panel indicator OFF)
T	Trigger Commands
T0	Continuous readings line synchronized
T1	Single reading line synchronized
T2	Continuous readings line asynchronous
T3	Single reading line asynchronous
P	Offset Commands
P0	Offset feature activated
P1	Offset feature disabled
X	Ext Ref — Scaling Command
X0	External reference scaling activated
X1	External reference scaling disabled
X2	Scaling mode activated

Limits-Peak Value Storage Commands	
U	Activate limits testing (value must be preset)
U0	Disables limits and Peak value storage testing
U1	Activate peak value storage
B	Control Commands
B0	Single byte binary
B1	Single character ASCII
B2	Double byte binary (16 bit-parallel)
B3	Double character ASCII (16 bit-parallel)
D	Disable front panel display (creates a local lockout)
D0	Activate front panel display
L	Activate local lockout
L0	Deactivate local lockout
Y	Echo capability activated (Full Duplex)
Y0	Echo capability disabled (Half Duplex)
J	Suppress line feed character
J0	Transmit line feed character
M	Inhibit Cal memory factors
M0	Enable Cal memory factors
K	Memory Commands
K0	Store last reading as offset
K1	Store last reading as VDC zero
KNP	Store last reading as ohms zero
KNX	Store following numeric value as offset
KNU	Store following numeric value as scaling factor
KNL	Store following numeric value as upper limit
G	Recall and transmit on trigger previous reading
G0	Recall and transmit on trigger DC zero
G1	Recall and transmit on trigger status
GNP	Recall and transmit on trigger offset
GNX	Recall and transmit on trigger scale factor
GNU	Recall and transmit on trigger upper limit
GNL	Recall and transmit on trigger lower limit
GNQ	Recall and transmit on trigger lowest peak value found
GNW	Recall and transmit on trigger highest peak value found

RESPONSES	
Measurement Responses	
Always in units of volts, ohms or amps.	
Typical response: "+19.26753E+3 <CR> <LF>"	
Response of "0<L K><LF>" indicates error in measurement.	
Limit Responses	
0	Reading within preset limits
+1	Reading exceeds upper limit
-1	Reading exceeds lower limit
+2	Error in measurement
Status Responses	
Typical "0 7 1 5 1 <CR> <LF>"	
	Function code
	Sample code
	Range code
	Error code
Status Message Error Codes	
00	No Error
06	System Error
07	Illegal Numeric Entry
08	Remote Command String Error
09	Remote Overrange
10	VDC Zero/Ohms Zero Error
11	Store during overrange
12	Filter module Faulty or not installed
13	DC Signal Conditioner Module Faulty or not installed
14	Excessive Voltage present at terminals for Ohms or Current Measurement

Table 605-2. Programming Commands (Concluded)

15	Fast A/D Converter Faulty or not installed
16	Numeric Display Overflow
17	Magnitude of External Reference Input >20V
18	Controller Module Faulty
19	Function Module selected not installed
Status Message Range Codes	
0	100 mV dc, 100 μ A, 10 Ω
1	1V dc, 1V ac, 1 mA, 100 Ω
2	10V dc, 10V ac, 10 mA, 1 k Ω
3	100V dc, 100V ac, 100 mA, 10 k Ω
4	1000V dc, 1000V ac, 1A, 100 k Ω
5	1 M Ω
6	10 M Ω
7	100 M Ω

Status Message Sample Codes	
0	1 sample per reading
1	2 samples per reading
2	4 samples per reading
3	8 samples per reading
4	16 samples per reading
5	32 samples per reading
6	64 samples per reading
7	128 samples per reading or greater
Status Message Function Codes	
0	DC Volts
1	AC Volts
2	DC Amps
3	AC Amps
4	Ohms
5	DC Coupled AC Volts
7	Function Not Defined

605-7. THEORY OF OPERATION

605-8. The function of the IEEE Interface is to facilitate communication between the instrument bus and the system bus. Section 3 of this manual explains the functioning of the instrument bus. The IEEE Standard specifies the construction and operation of the system bus. Signal lines in the system bus will be referred to here by their letter designations and will not be defined (refer to the IEEE Standard). The IEEE Interface is constructed on two boards mounted in the same module and connected together. The second board is called a Piggy Back board and has the same reference designators as are on the main board. To distinguish reference designators between the boards, a (PB) will follow the reference designator and the output pin (if applicable) will follow that as in this example: U11(PB)-13. This refers to a section of IC, U11, having an output on pin 13, located on the Piggy Back board. IC's on the main board will have no additional letter designations: U11-15.

605-9. Data Lines

605-10. Data lines (D101-D108) from the system bus are applied to the interface through receiver/drivers U21 and U24. The receivers are noninverting buffers. The drivers are gates with a common enable line from U32-8. Interface management lines employ the same type of receiver/drivers. Outputs from U21 and U24 are applied through inverters to a data register, U30 and part of U31. True conditions on the system data bus are defined as a low while true conditions on the instrument bus are defined as a high. Outputs from U21 and U24 are directly applied to address decoders U19 and U12, and through switch S1 to address decoders U6 and U3. The instrument data bus is applied to a response register, U26 and U29, where data is latched up for application to the system bus, which requires that data be held longer than is desirable to tie up the instrument controller. Instrument data is also applied to a control register, U11(PB), U16(PB), and U14(PB).

605-11. Addresses

605-12. Instrument address lines are applied to address decoders U12(PB)-6, U12(PB)-10, U13(PB)-6, U13(PB)-9, and U13(PB)-10. IC 1, 5, 4 high is decoded by U12(PB)-6 to enable the response register. IC 6, 4, 3 high is decoded by U12(PB)-10 to clock data into the control register and, if ID0 is high, to cause a Return to Local signal from U8(PB)-3. IC 5, 3, 0 high is decoded by U13(PB)-6 to cause a software reset through U8(PB)-10. IC 6, 0, 4 high is decoded by U13(PB)-9 to enable the status register, U28 and part of U31. IC 6, 1, 4 high is decoded by U13(PB)-10 to enable the data register, U30 and part of U31. All these addresses cause an ACK to be returned to the instrument controller through U6(PB)-1.

605-13. Addresses to the interface from the system must be accompanied by ATN true. My Listen Address (MLA) and My Talk Address (MTA) are received through S1 which sets both addresses with the first five bits. U6-13 decodes MLA which is clocked into U11-1 by the DAV signal. U3-13 decodes MTA which is clocked into U11-15 by the DAV signal. U19-13 decodes UNL (Unlisten) which clears the MLA flip-flop (U11-1). U12-10 decodes D102, D106, and D107 to enable (along with ATN) the Message Decoder, U9 (two sections), U5, and U8. Several interface control messages are conveyed on the system data bus which require decoding.

605-14. Resets

605-15. Two types of resets may occur: power-on reset and software reset. One input to U8(PB)-10 is an RC circuit whose time constant is longer than the time required for the logic supply, Vcc, to stabilize. Thus at power up, U8(PB)-10 causes an interface reset to prevent unwanted states in the interface logic. U13(PB)-6 decodes a software reset address. Software resets may occur as a result of a momentary power interruption (too short for C3(PB) to discharge), a front panel request or a system request.

605-16. Control Register

605-17. Six "D" flip-flops compose the control register, four of which accept data from the instrument controller when clocked by U12(PB)-10. U14(PB)-2 is an interrupt enable which remains true except during the power-up routine. U14(PB)-13 is used to initiate a service request (SRQ) to the system controller. U16(PB)-1 indicates when the instrument controller is ready for data (RFD). U11(PB)-13 goes true at the last data byte of a message to the system from the instrument controller. U16(PB)-13 is used to reset RFD and to send the data accepted (DAC) signal. U11(PB)-2 is used to generate the data available (DAV) signal when the instrument is a talker.

605-18. Status Register

605-19. The status register is composed of U28 and part of U31. The instrument address decoded by U13(PB)-9 enables a status byte to be placed on the data bus. ID0 is true from U28-7 when in the talk only mode. ID1 is true from U28-9 when remote enable (REN) from the System Controller is false. ID2 is true from U28-5 when go to local (GTL) is true from the message decoder, U5-4. ID3 is true from U28-3 when the interface receives my listen address (MLA) from U6-13. ID3 is also used as an identifier for the instrument controller in an interrupt. INA true enables a high on U28-11. ID4 is true from U31-3 for an interface message. ID5 is true from U31-5 indicating a device dependent message. ID6 is true from U31-7 during the serial poll mode when the system controller is requesting status. ID7 is true from U31-9 when the system controller is requesting data from the instrument.

605-20. Message Decoder

605-21. Interface messages sent by the system controller on the data bus are decoded by U9, U5, and U8. U8-4 goes true for the serial poll mode (SPE). U8-3 is true for serial poll disable (SPD). U5-3 is true for a local lockout (LLO). U5-4 is true for go to local (GTL). U8-10 is true

for selected device clear (SDC). U8-11 is true for group execute trigger (GET). U5-10 is true for device clear (DCL). GET, SDC, and GTL are device dependent messages which require the interface to be a listener before the instrument controller is interrupted. DCL and LLO are universal messages and are the only two which cause the instrument controller to be interrupted when in local.

605-22. Mode Register

605-23. The mode register consists of four J-K flip-flops: U15-15, U15-1, U11-15, and U11-1. U11-1 clocks in MLA. U11-15 clocks in MTA. U15-1 is true when in the remote mode. U15-15 is true when in the serial poll mode.

605-24. Instrument Interrupts.

605-25. Interrupts are enabled by U14(PB)-2 at all times except during the power-up routine. The interrupt flip-flop may be clocked by the DAV signal through U4(PB)-4 and U4(PB)-3, or by U6(PB)-13 when the instrument is to be an active talker.

605-26. TROUBLESHOOTING

605-27. Troubleshooting the IEEE Interface requires the use of an external I/O device such as an HP 9825 Calculator with an IEEE I/O. Due to the speed and complexity of the interface, it is recommended that faulty units be returned to a service center for repair. However, Figure 605-1 gives a symptom analysis approach to fault determinations.

605-28. PARTS LIST

605-29. Table 605-3 gives a parts breakdown for the IEEE Interface Option. Refer to Section 5 of this manual for ordering information.

CAUTION

Indicated devices are subject to damage by static discharge.

Figure 605-1. IEEE Interface Troubleshooting

SYMPTOM	POSSIBLE FAILURE
Display Blank Displayed Option Configuration Wrong Display Bad Doesn't Go into Remote	Piggyback board (P.B.) — Address decoders ACK always high P.B. — Address decoders or ACK circuit Main Board (M.B.) — Input latches or output buffers bad P.B. — INT Circuit not set M.B. — MLA Circuit (U6, U11) M.B. — Address switches bad or set wrong M.B. — (wrong data) IB buffers, GPIB chip M.B. — RFP signal held low M.B. — REN or DAV bad
Data Out Wrong Not Working On SRQs Can't Clear Interface Can't Go to Local or Lock Out FP Won't Go, TALK Only	Output latches and buffers, GBIP chip, UNL address circuit GBIP chip, status latches IFC circuit Decoder circuit (U9, U8) Status latches, TALK only circuit

Table 605-3. IEEE-488-1975 Interface Assembly

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART. NO. OR TYPE	TOT QTY	REC QTY	USE CDE
⊗	IEEE-488-1975 INTERFACE ASSEMBLY Figure: 605-2						
C1, C2	Cap, mica, 271 pF $\pm 5\%$, 500V	148452	72136	DM15271J	2		
C3	Cap, Ta, 10 uF, $\pm 20\%$, 15V	193623	56289	196D106X0015 KA1	1		
C4 thru C8	Cap, cer, 0.22 uF $\pm 20\%$, 50V	309849	71590	C30C224K	5		
C9	Cap, mica, 100 pF $\pm 5\%$, 500V	148494	72136	DM15102J	1		
CR1	Diode, Hi-speed switching	203323	07910	1N4448	1		
J2	Post Contact, 4 posts	417329	22526	65500-104	5		
J2	Post Contact, 12 posts	417337	22526	65500-112	3		
J3	Connecter, female, 24 pin	441337	13511	57-20240-8	1		
Q1	Xstr, Si, NPN	218396	04713	2N3904	1	1	
R1	Res, comp, 18k $\pm 5\%$, 1/4W	148122	01121	CB1835	1		
R2	Res, comp, 10k $\pm 5\%$, 1/4W	148106	01121	CB1035	1		
R3	Res, comp, 1k $\pm 5\%$, 1/4W	148023	01121	CB1025	1		
R4	Res, comp, 4.7k $\pm 5\%$, 1/4W	148072	01121	CB4725	1		
R5	Res, comp, 15k $\pm 5\%$, 1/4W	148114	01121	CB1535	1		
S1	Switch, module spdt, 5 pos	417766	00779	435470-4	1	1	
S2	Switch, slide, spdt	417287	95146	MSS-1040-1			
U1	⊗ IC, Dgtl, C-MOS, quad 2-input NAND gates	355198	02735	CD4011AE	1	1	
U2	⊗ IC, COS/MOS, dual, 4-input, NOR gates	363820	02735	CD4002AE	1	1	
U3, U6, U19	⊗ IC, Dgtl, C-MOS, 8-input, NOR gates	408781	02735	CF4078BE	3	1	
U4, U17	⊗ IC, Dgtl, C-MOS, quad, 2-input, AND gate	408401	02735	CD4081BE	2	1	
U5, U8, U14	⊗ IC, Dgtl, COS/MOS, quad 2-input, NOR gates	355172	02735	CD4001AE	3	1	
U7	⊗ IC, Dgtl, COS/MOS, triple, 3-input, NOR gates	355180	02735	CD4025AE	1	1	
U9	⊗ IC, Dgtl, C-MOS, dual, binary to 1-4 Dcdr/Muxr	408369	04713	MC14556CP	1	1	

Table 605-3. IEEE-488-1975 Interface Assembly (Concluded)

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART. NO. OR TYPE	TOT QTY	REC QTY	USE CDE
U10	⊗ IC, Dgtl, C-MOS, quad, 2-input, OR gate	408393	02735	CD4071BE	1	1	
U11, U15	⊗ IC, Dgtl, COS/MOS, dual, J-K master slave, flip flop	355230	02735	CD4027AE	2	1	
U12	⊗ IC, Dgtl, C-MOS, triple, 3-input, NAND gate	375147	02735	CD4023AE	1	1	
U13, U18	⊗ IC, Dgtl, C-MOS, hex, inverter	404681	02735	CD4069BE	2	1	
U16	⊗ IC, Dgtl, C-MOS, quad, 2-input, NAND S.T.	404632	02735	CD4039BE	1	1	
U20, U21, U24, U27	⊗ IC, Dgtl, quad, interface, bus transceiver	428649	04713	MC3446P	4	1	
U22, U25	⊗ IC, Dgtl, C-MOS, hex inverter/buffer	381848	02735	CD4049AE	2	1	
U26, U29	⊗ IC, Dgtl, COS/MOS, quad, clocked "D" latch	355149	02735	CD4042AE	2	1	
U28, U30,	⊗ IC, Dgtl, C-MOS, tri-state, hex non-inverting buffers	407759	12040	MM80C97N	3	1	
U32	⊗ IC, Dgtl, TTL, quad, 2-input, NAND gates	393033	01295	SN74LS00N	1	1	
U33, U34	Res Network	412916	89536	412916			
	Case half	402990	89536	402990	1		
	Case module, modified	456079	89536	456079	1		
	Cover, module case	402974	89536	402974	1		
	Decal, IEEE	413518	89536	413518	1		
	Guard, rear	383364	89536	383364	1		
	Screw, conn, mtg, (use on J3)	429472	89536	429472	2		
	Shield, cover	441022	89536	441022	1		
	Shield, front	383372	89536	383372	1		
	IEEE Piggy Back (Table 605-4)				1		

Table 605-4. IEEE-488 Piggy Back Assembly

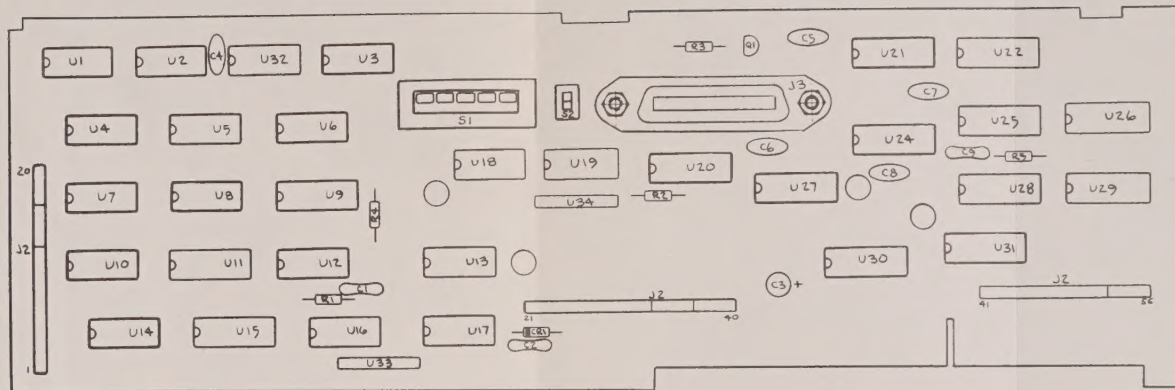
REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART. NO. OR TYPE	TOT QTY	REC QTY	USE CDE
⊗	IEEE-488-1975 PIGGY BACK ASSEMBLY Figure: 605-4						
C1, C4	Cap, mica, 270 pF $\pm 5\%$, 500V	148452	72136	DM15F271J	2		
C2	Cap, mica, 100 pF $\pm 5\%$, 500V	148494	72136	DM15F101J	1		
C3	Cap, Ta, 1 uF $\pm 20\%$, 35V	161919	56289	196D105X0035 JA1	1		
CR1	Diode, Hi-speed, switching	203323	07910	1N4448	1	1	
P2	Socket 4 pin	417311	20447	SS-109-1-04	5		
P2	Socket, 12 pin	417733	20447	SS-109-1-12	3		
P4	Binding Post	441741	89536	441741	1		
Q1	Xstr, Si, NPN	218396	04713	2N3904	1	1	
Q2	Xstr, Si, PNP	226290	04713	MPS3640	1	1	
R1, R5, R7	Res, comp, 10k $\pm 5\%$, 1/4W	148106	01121	CB1035	3		
R2, R6	Res, comp, 47k $\pm 5\%$, 1/4W	148163	01121	CB4735	2		
R3, R4	Res, comp, 150 $\pm 5\%$, 1/4W	147934	01121	CB1515	2		
R8	Res, comp, 15k $\pm 5\%$, 1/4W	148114	01121	CB1535	1		
R9	Res, selected, during test						
U1, U11, U14, U16	⊗ IC, C-MOS, dual, type "D" flip-flop	340117	02735	CD4013AE	4	1	
U2, U4	⊗ IC, Dgtl, COS/MOS, quad, 2-input, NOR gates	355172	02735	CD4001AE	2	1	
U3	⊗ IC, Dgtl, C-MOS, quad, 2-input NAND, ST	404632	02735	CD4039BE	1	1	
U5, U7	⊗ IC, Dgtl, C-MOS, hex inverter	404681	02735	CD4069BE	2	1	
U6	⊗ IC, COS/MOS, dual, 4-input NOR gates	363820	02735	CD4002AE	1	1	
U8, U9	⊗ IC, C-MOS, quad, 2-input NAND gates	355198	02735	CD0411AE	2	1	
U10	⊗ IC, Dgtl, C-MOS, hex, inverter/buffers	381848	02735	CD4049AE	1	1	

Table 605-4. IEEE-488 Piggy Back Assembly (Concluded)

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART. NO. OR TYPE	TOT QTY	REC QTY	USE CDE
U12	⊗ IC, Dgtl, C-MOS, triple, 3-input AND gate	408807	02735	CD4073BE	1	1	
U13	⊗ IC, Dgtl, C-MOS, triple, 3-input NAND gates	375147	02735	CD4023AE	1	1	

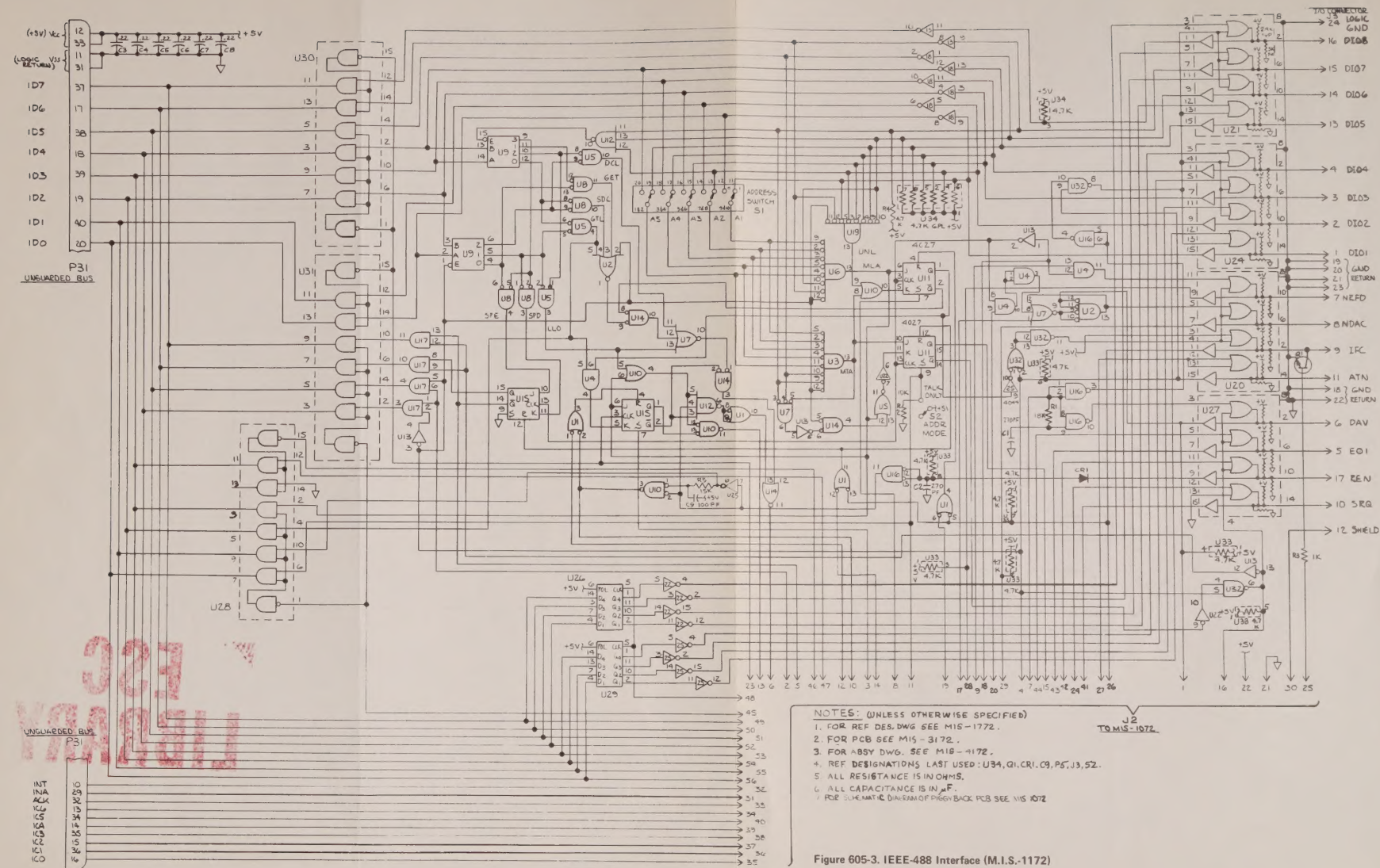
NOTES:

1. FOR SCHEMATIC DIAGRAM SEE M1S 1172.
2. FOR ASSEMBLY DRAWING SEE M1S 4172.
3. FOR PCB DETAIL DRAWING SEE M1S-3172.



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Figure 605-2. IEEE-488 Interface Assembly (M.I.S.-1772)



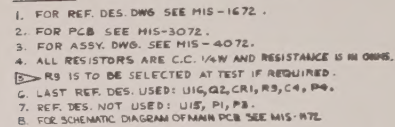


Figure 605-4. IEEE-488 Piggy Back (M.I.S.-1072)

NOTES

1. FOR SCHEMATIC DIAGRAM SEE M18-1072
 2. FOR ASSEMBLY DRAWING SEE M18-4072
 3. FOR PCB DETAIL DRAWING SEE M18-3072.
- ▲ R9 MAY NOT BE INSTALLED, SELECTED AT TEST.

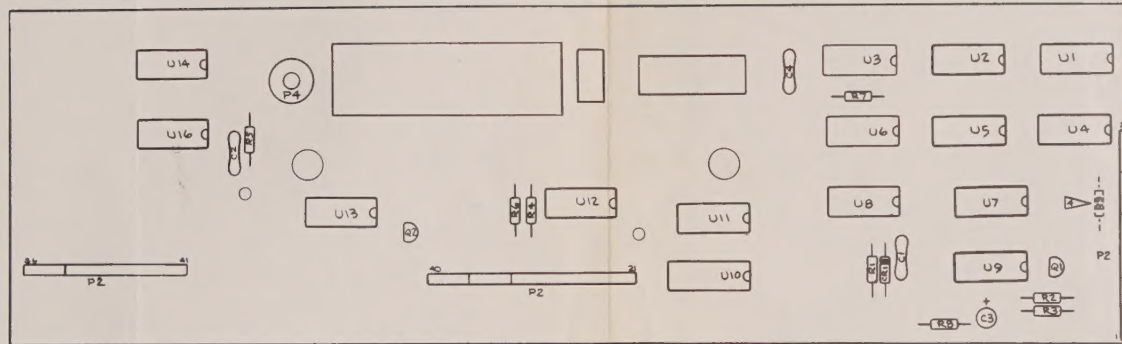


Figure 605-5. IEEE-488 Piggy Back Assembly (M.I.S.-1672)